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Proceedings Series 2003/004 | **Série des compte rendus 2003/004**

Proceedings of Three Workshops to Investigate the Unpacking Process in Support of Ecosystem – Based Management

Compte rendu de trois ateliers sur l'étude du processus de mise en oeuvre de la gestion écosystémique

February – July 2002 | **Février – Juillet 2002**

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February 2003 / Février 2003

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103-07350/

FOREWORD

The purpose of this proceedings is to archive the activities and discussions of the meetings, including research recommendations, uncertainties, and to provide a place to formally archive official minority opinions. As such, interpretations and opinions presented in this report may be factually incorrect or mis-leading, but are included to record as faithfully as possible what transpired at the meeting. No statements are to be taken as reflecting the consensus of the meeting unless they are clearly identified as such. Moreover, additional information and further review may result in a change of decision where tentative agreement had been reached

AVANT-PROPOS

Le présent compte rendu fait état des activités et des discussions qui ont eu lieu aux réunions, notamment en ce qui concerne les recommandations de recherche et les incertitudes; il sert aussi à consigner en bonne et due forme les opinions minoritaires officielles. Les interprétations et opinions qui y sont présentées peuvent être incorrectes sur le plan des faits ou trompeuses, mais elles sont intégrées au document pour que celui-ci reflète le plus fidèlement possible ce qui s'est dit à la réunion. Aucune déclaration ne doit être considérée comme une expression du consensus des participants, sauf s'il est clairement indiqué qu'elle l'est effectivement. En outre, des renseignements supplémentaires et un plus ample examen peuvent avoir pour effet de modifier une décision qui avait fait l'objet d'un accord préliminaire

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February 2003

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ISSN 1701-1280

Published and available free from:
Une publication gratuite de:

Fisheries and Oceans Canada / Pêches et Océans Canada
Canadian Science Advisory Secretariat / Secrétariat canadien de consultation scientifique
200, rue Kent Street
Ottawa, Ontario
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Printed on recycled paper.
Imprimé sur papier recyclé.

Correct citation for this publication:
On doit citer cette publication comme suit:

O'Boyle, R., and P. Keizer. 2003. Proceedings of Three Workshops to Investigate the Unpacking Process in Support of Ecosystem-Based Management; February – July 2002. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2003/004.

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ABSTRACT

Three independent workshops were held in Maritimes and Gulf Regions to test the usefulness of the ecosystem objectives framework developed at the "Sidney workshop." The main goal of the workshops was to investigate how operational objectives related to three activities (groundfish fishing, marine aquaculture, and offshore oil and gas exploration) could be developed. While the detailed outcomes of the workshops were different, in many ways, there was agreement that the framework was useful for evaluating operational objectives. There was also general agreement that care had to be taken in the wording of conceptual and operational objectives to reduce the potential for misinterpretation. There is a need for more regional and nationals discussions of the approach and more workshops to evaluate the framework for specific applications.

RÉSUMÉ

On a tenu trois ateliers indépendants dans les Régions des Maritimes et du Golfe en vue de déterminer l'utilité du cadre d'objectifs écosystémiques élaboré à « l'atelier de Sidney ». Ces ateliers visaient principalement à examiner comment on pouvait établir des objectifs opérationnels connexes à trois activités (pêche du poisson de fond, mariculture et exploration des hydrocarbures extracôtiers). Quoique, dans le détail, ces ateliers aient débouché sur des résultats différents à bien des égards, le cadre a été dans l'ensemble jugé utile à l'évaluation des objectifs opérationnels. On s'est également entendu sur le fait qu'il fallait faire attention à la façon dont étaient formulés les objectifs conceptuels et opérationnels pour réduire les risques d'interprétation fautive. Il est nécessaire d'avoir de plus amples discussions régionales et nationales sur l'approche ainsi que d'autres ateliers pour évaluer l'utilité du cadre dans certaines applications.

INTRODUCTION

In developed countries around the world, ways are being sought to manage human use of aquatic resources, taking into account our existing knowledge about ecosystem structure and function. For instance, a major element of the ICES Strategic Plan (Anonymous, 2001) is the development of an ecosystem-based approach to conducting aquatic resource assessments and providing advice. Australia is actively promoting informed management of its ocean resources (e.g. Garcia and Staples, 2000) and numerous initiatives are underway in Canada to operationalize its 1997 Oceans Act. In June 2000, DFO National Policy Committee endorsed an approach to incorporating ecosystem considerations within fisheries and oceans management. A departmental Working Group on Ecosystem Objectives (WGEO) was established to undertake further work on the approach, including developing an operational definition for ecosystem objectives. In March 2001, a National workshop was held on "Objectives and Indicators for Ecosystem-based Management." One of the products of this workshop (Jamieson et al., 2001) was a draft framework for identifying conservation objectives for ecosystem-based management (EBM). This workshop, which was held at Dunsmuir Lodge in Sidney, B.C., is commonly referred to as the "Sidney workshop". One of the recommendations of this workshop was to 'road-test' the concepts discussed through regional pilots.

The WGEO is leading national efforts on these regional pilots. The Eastern Scotian Shelf (ESS) has been chosen as a national pilot area due to the extensive work already underway relevant to the pilots. The WGEO is to undertake an illustrative project (to be completed in early 2003) to explore how ecosystem-based management in the area might be achieved. During 2003, and building upon the illustrative project, the WGEO is to undertake a pilot project on the ESS, which will be a more in-depth project to investigate how EBM might be implemented on the ESS. This project would engage clients as part of the exercise. Both initiatives are to be conducted in parallel to the ESSIM initiative and could eventually provide all IM projects in Canada with an EBM framework.

Three workshops were conducted during 2002 to provide background on the activities of the WGEO and to undertake exploratory 'unpacking' exercises to test the overall approach to defining ecosystem-level objectives, as proposed in Sidney and thus to investigate ways the impacts of groundfish fishing, aquaculture activities and oil and gas development on the ecosystem could be assessed. The three workshops were planned and conducted independently. However, once they were completed, common features were noted and it was considered worthwhile capturing the proceedings of the three in one report.

This report presents the discussion conducted at each meeting, along with the generated illustrative unpacking tables. The most extensive unpacking was that of aquaculture. The minutes of aquaculture and oil and gas meetings had been reviewed previously by their participants. Here, they were re-organized into a

common format. The proceedings also provides an overview of the comments, with observations by the authors on the utility of the approach and how it might be pursued in the future.

IMPACTS OF GROUNDFISH FISHING

1 February 2002
6th Floor Boardroom, BIO, Dartmouth, NS

Background

Recently, DFO has undertake a review of its fishery planning process, with the aim being more formal recognition in management plans of objectives and how regulations link to these. Termed Objectives Based Fisheries Management (OBFM), it is expected that all East Coast fishery management plans will follow the same overall OBFM template. To test implementation of OBFM, pilots have been chosen in each region. In the Maritimes, the Scotia-Fundy groundfish and Bay of Fundy Scallop fisheries have both been designated as pilots. At the time of this meeting, the groundfish pilot was to have an OBFM plan in place as of April 1, 2002. It subsequently did produce this plan on schedule as required. It was considered useful to undertake an illustrative unpacking of the Sidney workshop objectives to explore how ecosystem issues might eventually be incorporated into the plan, with no commitment to incorporate the results of the unpacking into the current document. Notwithstanding this, the exercise did ultimately influence the ecosystem objectives structure of the plan (see Table 1 of annex 2 (p6) for the plan version adopted).

Workshop Approach

After welcoming the participants (Appendix 1) and reviewing the agenda (Appendix 2), the chair gave a brief overview of the ecosystem objectives (Figure 1) as described by Jamieson et al (2001) along with some ideas on the socio-economic / institutional dimensions taken from the literature. This was followed by a briefing on terminology being used and a general discussion on the objectives. The rest of the meeting then systematically considered each of the Sidney meeting objectives and the group attempted to unpack each objective to a point which it might be considered operational.

Results of the Unpacking

The exercise focused on the diversity and productivity objective and unpacked twelve operational objectives (Table 1). As much as possible, the exercise restricted itself to objectives that are currently either in place or being considered.

In Table 1, the left-hand column states the high-level ecosystem objective and the unpacked conceptual objectives related to it. At the point where an operational objective (verb, indicator and reference point) could be stated, this is provided in the

right hand column. As much as possible, all steps of the unpacking are provided to allow understanding of how the unpacking actually unfolded.

While the exercise was successful in identifying indicators related to some of the objectives, much work remains to be done, both on indicators for some of the objectives and reference points for most.

Table 1. Results of the Impacts of the Groundfish Fishery Unpacking Exercise.

Conserve Ecosystem Components

Conceptual Objective	Operational Objective
❖ Maintain Community Diversity ➢ Maintain Benthic Communities • Protect benthic communities susceptible to bottom disturbance • Limit bottom disturbance of each benthic community • Protect high diversity coral beds in the Northeast Channel • Protect all benthic communities in the Gully ❖ Maintain Pelagic Community • Further unpacking required	• Limit % of coral area disturbed by bottom fishing to zero • Limit % of area disturbed by bottom fishing to zero
❖ Maintain Species Diversity ➢ Maintain continued existence of all species within management area • Minimize impact on non-target / commercial species • Limit catch of skate • Minimize impact on non-target / non-commercial species • Limit mortality of sculpin, etc • Protect species at risk • Minimize catch of turtles • Prevent catch of right whales • Minimize catch of harbour porpoise • Minimize catch of groundfish species under SARA • Manage exploitation of target species • Avoid recruitment overfishing • Maintain all target species above conservation limits • Cod • Haddock • Pollock	• Limit catch of skate to TAC • To be defined • To be defined • Limit take of right whale to zero • Limit take of porpoise to specific rate e.g. 111 / year • To be defined • Maintain cod abundance above conservation limit (CL) • Maintain haddock abundance above CL • Maintain pollock abundance above CL

Conceptual Objective	Operational Objective
❖ Maintain Population Diversity ➢ Maintain continued existence of all populations within management area • Maintain spawning components i.e. populations • Ensure that no spawning component is eliminated by fishing • Distribute fishing over spawning components	• Limit exploitation on spawning component x to y

Conserve Component's Role

Conceptual Objective	Operational Objective
❖ Maintain Primary Productivity • Not relevant to fishing activity	
❖ Maintain Trophic Structure • Further unpacking required	
❖ Maintain Productivity of Populations ➢ Manage exploitation of target species ▪ Control overall exploitation rate ▪ Ensure appropriate size selectivity of fishery ▪ Prevent disturbance of fish when spawning	• Limit exploitation to less than x • Limit catch of species x below size y to x % by number • Prohibit fishing during spawning season

IMPACTS OF AQUACULTURE ACTIVITIES

25-26 June 2002
Gulf Fisheries Centre, Moncton, NB

Executive Summary

During June 25 – 26, 2002, a workshop was held at the Gulf Fisheries Centre in Moncton, N.B. to "unpack" the ecosystem objectives framework in the context of potential impacts from coastal mariculture development. This was an internal Fisheries and Oceans Canada exercise involving Maritimes and Gulf Region scientists with expertise on aquaculture impacts and previous experience with "unpacking" the ecosystem objectives framework. The meeting focussed on formulating conceptual objectives for the "habitat branch" of the framework that led to a template for the operational objectives. Under the overarching objective of conservation of species and habitat, the workshop defined objectives related to biodiversity, productivity and the physical and chemical properties of the ecosystem. Under each of these, further nested components were defined, along with an 'unpacking' process to link these conceptual objectives to those suitable for operational management. For each nested component, a suite of biological properties or characteristics was developed that further described the objective. Example indicators and reference points were also developed by operational objective, although further work on these at both a national and regional level is required.

Assessment frameworks that evaluated progress against all objectives simultaneously were discussed and their potential uses investigated. Finally, the workshop developed a list of issues and proposed next steps, including recommendations for further research, that DFO would need to address to further the implementation of ecosystem-based management in Canada.

Background

Within DFO Maritimes Region, the development of a sustainable aquaculture industry has been a focus of research activities for the past 15 years. As a result, in the Region, there are a number of researchers who have accumulated considerable knowledge regarding the impacts of mariculture on marine ecosystems. In June 2001, the Maritimes Region's Joint Branch Management Committee requested that a "RAP workshop on the impacts of salmon aquaculture on the Bay of Fundy ecosystems, using the framework for definition of ecosystem objectives and indicators developed at the Dunsmuir workshop" be undertaken. Through discussion, it was determined that a RAP meeting was not required at this time since no formal request for advice could be identified. However, it was decided that it would be useful to try to 'unpack' the ecosystem objectives framework, as recommended at the Sidney workshop, in the context of the extensive regional knowledge of the impacts of aquaculture. The term "unpacking the framework" refers to the development of a hierarchy of conceptual objectives culminating in operational objectives with associated targets and reference points. Since the Sydney workshop, "unpacking" exercises had been conducted for groundfish (see above) in Maritimes Region. This exercise would be the first unpacking of the framework in the context of the impact of aquaculture.

Workshop Approach

Since the primary purpose of the workshop was to investigate the draft framework from the Sidney workshop, participation (Appendix 1) was limited to DFO experts. A number of the participants were involved in the preparation of a national review document on the impacts of aquaculture. The authors kindly made these draft documents available to participants prior to the meeting. In addition, a number of other relevant documents had been provided, including the report of the Sidney workshop on "Objectives and Indicators for Ecosystem-based Management." These documents provided a common starting point for all participants.

On the first morning, there were presentations (Appendix 2) to provide background, after which the participants were divided into two breakout groups. These were tasked to 'unpack' the Sidney workshop draft framework as far as possible with the goal to formulate potential operational objectives for the impacts of aquaculture on coastal ecosystems. The main goal was to determine if the framework was generally useful for examining the impact of aquaculture activities. The expected outcomes were to be observations on the usefulness of the approach, comments on

the validity of the draft framework, and unpacking of the framework in the context of aquaculture impacts to the extent possible.

The groups reconvened in plenary to discuss their progress, after which presentations were given that were selected to assist the discussions. Paul Fanning presented the use of the Traffic Light Approach for providing stock assessment advice. Barry Hargrave used the same approach as the basis of a decision support system to provide advice to Habitat Management on aquaculture site applications. An alternate approach to integrating a wide range of information, the Index of Biotic Integrity, was presented by Andrea Locke. Sophie St.-Jean presented the results of her research in Pictou Harbour investigating the utility and sensitivity of various indicators of biological impacts.

On the second day, after a short plenary session, the same breakout groups reconvened to complete the exercise. The meeting ended with a plenary discussion of the results, reported below, from the two groups.

The starting point of discussions was the draft framework (Figure 1 (Fig 2 from Jamieson et al., 2001)). At the highest level of the hierarchy, the objectives split into two overarching goals – Sustainability of Human Usage (socio-economic dimensions) and Conservation of Species and Habitat (environmental dimension). As with the Sidney workshop, it was agreed to restrict the discussion to the environmental dimension. The selection of the operational objectives to ensure conservation of species and habitats could be made by science alone. However, when targets for operational objectives were being established, input from all stakeholders would be required.

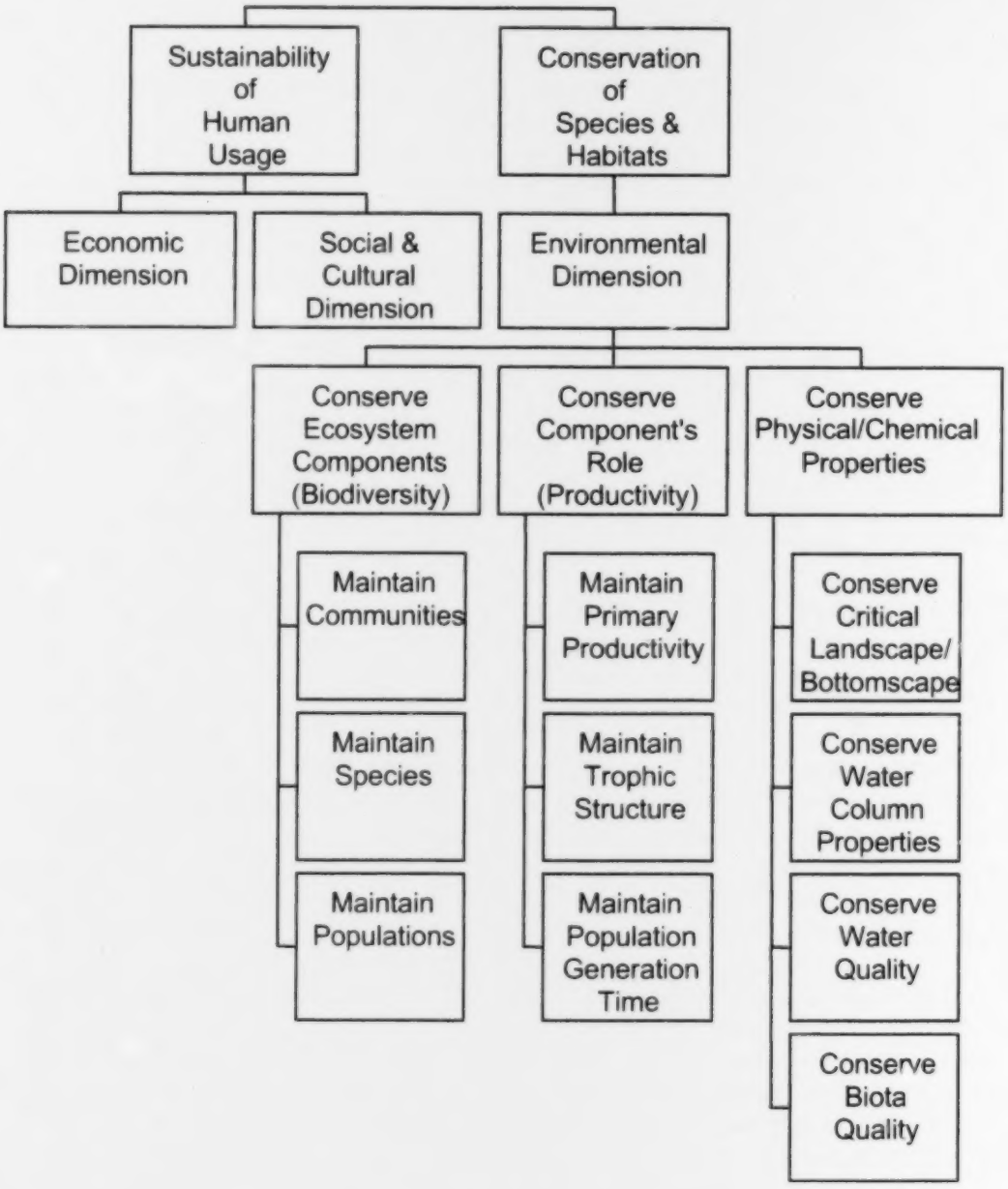

Figure 1. Ecosystem Objectives Structure as described by Jamieson et al. (2001).

After discussion about the three objectives of the environmental dimension (diversity, productivity and physical/chemical properties), it was decided to proceed with the draft structure and then analyse the outcome. These three objectives are hereinafter referred to as the three branches of the framework.

It was agreed that it would not be practical or appropriate at this meeting to discuss targets for identified operational objectives. As indicated earlier, "non-science" input would be required in the setting of most targets. Even focussing on targets that could be associated with Section 35 of the Fisheries Act would require a determination of what would constitute a "harmful" alteration of habitat (HADD). It was agreed that the role of science would be to advise on the potential consequences of selecting a particular target. An evaluation of the potential risks could lead to the application of the precautionary approach (PA). It was noted that the accepted definition of the PA in Canada was extremely narrow and was limited to instances where there was a serious risk of irreversible damage.

Observations of the Breakout Groups

Independently, both breakout groups focused on the "Conserve Physical / Chemical Properties" branch of the framework. Discussions in the two groups were quite different but also had common themes and identified similar issues. The results of the unpacking by the two groups are shown in Table 2. Both groups concluded that there was a deficiency in the draft framework with respect to the treatment of surface sediment as habitat. In general, the lack of or presence of detail for a particular part of the framework resulted from a combination of the general approach taken by the particular group and the specific expertise present in the group. A general observation was that the framework needs to remain as generic as possible at all levels in order to prevent the development of a framework that is so complex that it is unwieldy.

An attempt was made to unpack the other two branches of the framework, ecosystem structure (diversity) and function (productivity), based on a "strawman" outline (Appendix 3) provided by R. O'Boyle. The absence of a discussion to develop a consensus on the exact meaning of the conceptual objectives appeared to hinder agreement on appropriate operational objectives. Some of the observations that were made during the discussions included:

With respect to maintaining communities:

- What community attributes are important to maintain?
- What is the spatial scale of concern?
- Is the concept of rare communities relevant or valid?
- Knowledge is required to describe communities and identify rare communities in a particular area
- Will maintenance of species ensure maintenance of communities?

With respect to introductions both intentional and unintentional:

- There are both functional (biological) and structural (habitat) concerns.
- Creation of new habitat can favour opportunistic species, e.g. tunicates on mussels, epiphytes on finfish cages, and Enteromorpha on protective nets used in clam culture.

The need for a top down approach to unpacking the framework was reinforced by a problem encountered during these discussions. It was felt that the three conceptual objectives "maintain communities", "maintain species", and "maintain populations", were in many ways redundant. Whether such redundancy is a useful feature of the framework should be clarified with further testing. It was pointed out that at the Sidney workshop, the "maintain species" objective was specifically directed at endangered or threatened species.

Observations of the Plenary Sessions

During the plenary sessions, there were a number of issues identified as requiring further consideration.

Scale

Scales, both temporal and spatial, need to be considered when unpacking the framework. For finfish aquaculture operations, it was noted that there were at least three relevant spatial scales: local (i.e. beneath the cages), bay area or coastal management area (CMA) (i.e. an embayment that contained one or more sites), and regional (i.e. a coastal area such as the Western Isles Region or Large Ocean Management Areas (LOMAs)). Introduction of "scale" into the framework resulted in the subsequent "branches" repeating themselves. This was an indication that the "branching" had occurred too soon. Another option is to consider scale when the operational objective is being articulated and the targets determined. It was agreed that further discussions are needed to clarify the incorporation of temporal and spatial scales into the framework.

Operational Objectives – Non-science Aspects

Quite often, the attempts to clearly articulate an operational objective resulted in the use of adjectives such as "acceptable", "significant", "desirable", or "baseline". There are many factors that determine what is considered acceptable or significant or what is a suitable baseline. There are scientific arguments, legal requirements, social preferences and economic considerations. It was agreed that further discussion was required to find a systematic way for engaging science in the definition of these "soft" targets. Until these soft targets are defined, the formulated objectives are still conceptual and not operational.

Horizontal Relationships

Articulating an operational objective for the "habitat" branch of the framework often resulted in making reference to a biological requirement that would be defined by the unpacking of the "ecosystem function" or "ecosystem structure" branches of the framework. The examples encountered during this exercise were convergent in nature, i.e. a common operational objective with a similar limit as a result of unpacking different branches of the framework. Concern was expressed that divergence was also a possible result and the potential for this outcome needs to be explored. Once the social / economic objectives are merged with the ecosystem objectives, divergence is more likely. Several reasonable scenarios were discussed where the ecosystem and social / economic targets could be in conflict. Further unpacking exercises are needed to investigate this aspect of the framework.

Sidney Objectives Framework

Some details of the draft framework were found to be awkward. This could be partly a result of the absence of information on the intended meaning of a conceptual objective. As noted earlier, it was discovered that the objective to "maintain species" identified at the Sidney workshop referred specifically to endangered or threatened species. A comprehensive exercise to unpack all three branches of the framework is needed to verify that all are necessary. The integrity of the framework should be tested at all levels. This can be done by asking two questions at any level in the framework. The answer to "why do I need to know or do this?" should be found in the level above. The answer to the question "what do I need to know or do to do this?" should be found at the level below.

Careful consideration should be given to altering the basic structure of the framework. Given that the fundamental goal is sustainable use, in the broadest sense, of aquatic resources, the present structure appears to lack integrity. Sustainable use, in the broadest sense, includes not only resource extraction but also appreciation of our oceans and their contents for their intrinsic values. Thus "Conservation of Species and Habitats" is a means of conserving the function of the ecosystem, which is a means to sustaining human use.

There are also a number of changes to the "habitat" branch of the framework that are necessary. Two conceptual objectives are needed for surface sediments comparable to those for water, i.e. conserve surface sediment properties and conserve surface sediment quality. As well, the conceptual objective "Conserve biota quality" is out of place in the framework or the title conveys the wrong meaning. If it was meant to refer to the use of biota as habitat, then it should be covered under "Conserve critical landscape / bottomscape."

Results of the Unpacking Exercise

The results of the unpacking exercises are presented in Table 2. Group 1 had more of a tendency to identify objectives at or close to the operational level and to make particular reference to aquaculture impacts. In a number of instances, mitigation or management actions were also identified. Group 2 chose to focus more on unpacking the conceptual part of the framework in order to develop a consensus on the exact meaning of the overall objective. For the most part, both groups identified the same issues, although there were differences. For example, the two groups differed in the material that was considered under "Conserve Water Quality" and "Conserve Water Column Properties." However, both groups identified a very similar set of issues in total. One group did not identify the quality of the sound environment in their breakout group but quickly added it to their list when the other group identified it.

The column in Table 2 with the heading "Proposed" is an attempt to extract from the two group reports the elements for which there was apparent consensus at the conceptual level. In most cases, the groups did not reach a consensus on an objective that could be considered truly operational. However, there was discussion about the nature of these objectives. Table 3, prepared by R. O'Boyle, based on the "Proposed" conceptual framework from Table 2 includes examples of the types of operational objectives that could result from a complete unpacking exercise.

Concluding Remarks

Most participants generally found that the unpacking exercise generated useful discussion. However, it was just the beginning towards the development of a framework that could be used as an aid for decision making on research priorities and determining operational objectives and reference points.

The framework has a utility for identifying research needs. One of the clear outcomes of this exercise was the recognition that operational objectives would often be difficult to identify due to a lack of knowledge. For example, in order to protect the survival of an endangered species, protection of its essential habitat would be required. However in most instances, there is little knowledge of the habitat requirements of the various life stages of most marine organisms.

The framework has potential utility for directing discussions to determine the potential significance of impacts of human activities on fish habitat and to identify relevant monitoring and associated targets and reference points. The practicality of such an approach may be limited by our knowledge as noted above.

Similarly, the framework has potential utility for directing discussions on ecosystem objectives (or MEQ objectives) for MPAs subject to the limitations mentioned above.

There is a need to "unpack" the rest of the framework and determine the horizontal linkages among the three environmental branches. This could lead to a revision in the structure of the framework. The present structure implies that operational objectives for conserving ecosystem structure, ecosystem function, and habitat could be set independently. This appears to be a carryover from past approaches to the management of marine resources.

"Unpacking" exercises should continue to focus on the development of a robust generic framework at the conceptual level before external stakeholders are engaged and efforts are made to develop operational objectives and their associated reference points.

There needs to be better communication among the regions on these "unpacking" exercises. At this workshop, it was noted that an unpacking exercise was held for the Pacific Region's Central Coast Integrated Management project and prospective LOMA's on Newfoundland's East Coast. Communication of the results of the exercises and the process used for the exercises would benefit future undertakings.

Table 2: Resulting ecosystem objectives framework from the unpacking exercise for the two breakout groups and a proposed consensus framework. The framework begins with the conceptual objective "Conserve Physical and Chemical Properties." The next level of conceptual objectives taken mostly from the report of the Sidney workshop is in bold typeface. Proposed conceptual objectives from this meeting are in san serif font. The level of indentation indicates progress towards an operational objective.

Conserve Physical and Chemical Properties

Group 1	Group 2	Proposed
Conserve critical landscape and bottomscape features		
Maintain natural abiotic and biotic structures relative to environmentally acceptable conditions / baseline (predevelopment)?	Conserve benthic structural/functional features (abiotic and biogenic)	Conserve benthic structural/functional features (abiotic and biogenic)
Minimize loss of critical local structures to x%	By maintaining topography, sediment structure	By maintaining topography, sediment structure
Maintain % cover of bottom type X to below Y%	By maintaining natural scales of physical/biological variability (i.e. structural, heterogeneity, patchiness, complexity, sediment texture, bottom relief)	By maintaining natural scales of physical/biological variability (i.e. structural, heterogeneity, patchiness, complexity, sediment texture, bottom relief)
	By maintaining essential/critical habitat	By maintaining essential/critical habitat
		Limit % cover of bottom type X to below Y%
Conserve Bottom Sediment Quality	*Conserve Sediment Physical Structure and Chemical Properties*	*Conserve Bottom Sediment Quality*
Maintain geochemical conditions to acceptable levels (MEQ)	Conserve physical and chemical properties that support biological structure and function	Maintain physical and chemical properties that support biological structure and function
If EH, sulfide, organics water content, and / or grain size are above RP, implement mitigation	By maintaining natural variability in surficial sediment porosity, interstitial space, DO penetration	By maintaining natural variability in surficial sediment grain size, porosity, interstitial space, DO penetration
Conserve Bottom Sediment Quality (cont'd)	*Conserve Sediment Physical Structure and Chemical Properties (cont'd)*	*Conserve Bottom Sediment Quality (cont'd)*
Limit anthropogenic inputs from aquaculture operations	By maintaining natural geochemical conditions (e.g. $S^{=}$, Eh, quality and quantity of organic matter, C_{org}:N)	By maintaining natural geochemical conditions (e.g. $S^{=}$, Eh, quality and quantity of organic matter, C_{org}:N)

Conserve Physical and Chemical Properties

Group 1	Group 2	Proposed
If heavy metals, drugs, pesticides, etc are above RP, implement mitigation	By maintaining conditions for natural microbial community function (e.g. benthic aerobic/anaerobic respiration)	By maintaining conditions for natural microbial community function (e.g. benthic aerobic/anaerobic respiration)
	By maintaining variation in scales of benthic habitat heterogeneity	By maintaining variation in scales of benthic habitat heterogeneity
	By maintaining natural variability in surficial sediment trace metal content (Li-normalized).	By maintaining natural variability in surficial sediment trace metal content (Li-normalized).
		By maintaining concentrations of organic contaminants (including pesticides, PAHs, therapeutants etc) to acceptable levels.

Conserve Water Column Properties		
Maintain water currents relative to acceptable conditions / baseline?	Conserve physical properties (e.g. currents, stratification, temperature)	Maintain physical properties (e.g. currents, stratification, temperature)
Minimize profile of site through design and placement	By maintaining water mass movement (vertical / horizontal structure, velocity)	By maintaining water mass movement (vertical / horizontal structure, velocity)
Further unpacking required	Maintain water flow within natural limits of variation	
Maintain physical features (ice cover, currents, fronts, stratification, freshwater inputs) at historical average levels	Conserve properties that support biological structure and function	Maintain properties that support biological structure and function
Further unpacking required	By maintaining temperature and salinity structure	By maintaining temperature and salinity structure
Maintain sound quality within environmentally acceptable levels	Maintain natural temperature and salinity structure	Maintain light spectral quality
Do not use sound at x frequency and y intensity during z season		By maintaining acceptable levels of SPM

Conserve Physical and Chemical Properties

Group 1	Group 2	Proposed
Conserve Water Column Properties(cont'd)		
	Maintain light penetration	Maintain underwater sound (quality / quantity)
	By maintaining acceptable levels of SPM	
	Conserve underwater sound (quality / quantity)	
	By maintaining natural sound frequencies	
Conserve Water Quality		
Maintain dissolved oxygen within environmentally acceptable levels	Maintain dissolved oxygen and nutrients with ranges of natural variation	Maintain dissolved oxygen at levels to support natural ecosystem functions
If DO concentration deviates outside range of low & high RP, undertake mitigation	Maintain dissolved oxygen within normal levels (80% saturation or range of natural variation)	Maintain nutrients at levels to support natural ecosystem functions
Maintain nutrients within environmentally acceptable levels		Maintain levels of contaminants below levels at which biological effects are observed
If nutrient loadings are above environmentally acceptable levels, undertake mitigation.		
Further unpacking required: RPs must be determined in context of receiving environment		
Maintain temperature and salinity		
Further unpacking required		
Maintain light spectral quality		
Limit dissolved and particulate inputs from aquaculture activities to environmentally acceptable levels		
If input x is above RP, undertake mitigation.		
Limit activities that directly influence light field		

Conserve Physical and Chemical Properties

Group 1	Group 2	Proposed
Conserve Water Quality (cont'd)		
Limit shading of site to x% cover Limit candle power to below RP Limit activities that indirectly influence light field Further unpacking is required Limit anthropogenic inputs Limit anthropogenic inputs from aquaculture operations		
If heavy metals, drugs, pesticides, etc are above RPs, implement mitigation Limit anthropogenic inputs from activity x		
Conserve Biota Quality		
Maintain health of wild organisms	Limit contaminant loads in biota	Maintain health of wild organisms
Limit contaminants to below biologically acceptable levels	By maintaining concentrations of accumulated contaminants below impact thresholds of biological effects (e.g. impact on growth, reproduction, alteration of endocrine function in a target species, survival)	Limit contaminants to below biologically acceptable levels

Conserve Physical and Chemical Properties

Group 1	Group 2	Proposed
Conserve Biota Quality (cont'd)		
Do not exceed standards for contaminant loads	Maintain concentrations of X below Y	Avoid impacts on biological function (ecosystem structure and function)
E.g. tissue residue in species x of contaminant y should not exceed RP	Monitor biological function to determine deviation from the norm	Avoid food chain contamination
Limit disease impact of aquaculture activities	Avoid impacts on biological function (ecosystem structure and function)	
Further unpacking is required	By ensuring that accumulation of contaminants is below levels for impacts on ecosystem structure and biological function	
	Observe impacts (establish cause / effect relationships)	
	Avoid food chain contamination	
	Monitor / control chemical discharges	

Table 3. Examples of operational objectives for the "Proposed" conceptual framework of Table 2

Conceptual Objective	Operational Objective
❖ Conserve critical landscape and bottomscape features	
➢ Conserve benthic structural/functional features (abiotic and biogenic)	
▪ By maintaining topography, sediment structure	• Limit % cover of bottom type X to below Y%
▪ By maintaining natural scales of physical/biological variability (i.e. structural, heterogeneity, patchiness, complexity, sediment texture, bottom relief)	• Limit % cover of bottom type X to below Y%
▪ By maintaining essential/critical habitat	• Limit % cover of bottom type X to below Y%
❖ Conserve Bottom Sediment Quality	
➢ Maintain physical and chemical properties that support biological structure and function	
▪ By maintaining natural variability in surficial sediment porosity, interstitial space, DO penetration	
• Further unpacking required	
▪ By maintaining natural geochemical conditions (e.g. $S^{=}$, Eh, quality and quantity of organic matter, C_{org}:N)	• Maintain EH, sulfide, organic water content, and / or grain size above Reference Point (RP)
▪ By maintaining conditions for natural microbial community function (e.g. benthic aerobic/anaerobic respiration)	
• Further unpacking required	
▪ By maintaining variation in scales of benthic habitat heterogeneity	
• Further unpacking required	
▪ By maintaining natural variability in surficial sediment trace metal content (Li-normalized).	
• Further unpacking required	
❖ Conserve Water Column Properties	
➢ Maintain physical properties (e.g. currents, stratification, temperature)	
▪ By maintaining water mass movement (vertical / horizontal structure, velocity)	
• Further unpacking required	
➢ Maintain properties that support biological structure and function	
▪ By maintaining temperature and salinity structure	• Maintain water temperature between x and y degrees • Maintain water salinity between x and y ppt
➢ Maintain light spectral quality	
▪ Limit dissolved and particulate inputs from aquaculture activities to environmentally acceptable levels	• Maintain input x below RP
▪ Limit activities that directly influence light	• Limit shading of site to x% cover

Conceptual Objective	Operational Objective
field ▪ Limit activities that indirectly influence light field • Further unpacking required ➢ Maintain underwater sound (quality / quantity)	• Limit candle power to below RP • Do not use sound at x frequency and y intensity during z season
❖ Conserve Water Quality ➢ Maintain dissolved oxygen at levels to support natural ecosystem functions ➢ Maintain nutrients at levels to support natural ecosystem functions ▪ Further unpacking required: RPs must be determined in context of receiving environment ➢ Maintain levels of contaminants below levels at which biological effects are observed	• Maintain DO concentration within range of low & high RP • Limit heavy metals, drugs, pesticides, etc inputs to below RPs
❖ Conserve Biota Quality ➢ Maintain health of wild organisms ▪ Limit contaminants to below biologically acceptable levels ▪ Limit disease impact of aquaculture activities • Further unpacking required ▪ Avoid impacts on biological function (ecosystem structure and function) • By ensuring that accumulation of contaminants is below levels for impacts on ecosystem structure and biological function ♦ Further unpacking required ▪ Avoid food chain contamination • Further unpacking required	• Do not exceed standards for contaminant loads E.g. tissue residue in species x of contaminant y should not exceed RP

IMPACTS OF OIL AND GAS ACTIVITIES

29 July 2002

Hayes Boardroom BIO, Dartmouth, NS

Background

The chair welcomed the participants (Appendix 1) after which it was noted that as this was an illustrative exercise not intended to define concrete objectives, attendance could be restricted to experts immediately familiar to oil and gas issues. He then presented the meeting background and summarized the conceptual objectives for EBM as proposed in Sidney. He then described the unpacking process to be used to produce operational objectives from the conceptual ones. Following this and the ensuing discussion, the unpacking structure developed in the aquaculture workshop was presented and used as a starting point for the oil and gas unpacking. It was noted that oil and gas activities involve exploration, production, transport and abandonment. This exercise would only address exploration, with further future unpacking exercises required for the other activities.

Concern was expressed that the Jamieson et al. (2001) framework represented a narrow, DFO, perspective on resource management, whereas the management of oil and gas projects involves other departments and levels of government. It was considered that the hypothetical unpacking would be a useful exploratory exercise, even though there will probably be additional over-arching governmental objectives for oil and gas management.

Observations of the Workshop

Sidney Objectives Framework

The overall structure (Figure 1) was considered generally good and useful in addressing and gas issues. some specific concerns were raised, however, that require further consideration.

There is a problem with terms such as 'maintain' and 'conserve' being used for different branches. A common and general wording is preferable. It was recognized that the meaning of the objectives would become specified as a consequence of the unpacking. However, this highlights the need for wording that will not be easily misconstrued in this process. The group chose the terms ' no significant adverse alteration' to replace the above wording.

There was discussion on the diversity and productivity branches, mostly to clarify their intent. When it was noted that these two branches referred to the structure and function of the ecosystem, it was suggested that these words be explicitly built into the structure. The point was made that similar clarification exercises should be made across Canada. Indeed, this might be a consequence of the WGEO pilot projects.

Most of the comments related to the physical/chemical branch. It was felt that there were too many sub-objectives at this level. Three, covering seabed, water quality and biota quality were considered sufficient. It was noted that the aquaculture workshop had added sediment, to have five sub-objectives. Here, sediment was added under seabed. It was felt that parsimony in the structure was a virtue, as different groups would tend to add their preferences to the structure if not controlled. A common, simple, structure was endorsed.

It was noted, as at the aquaculture workshop, that in some cases meeting objectives down one branch would likely infer meeting them down another. This redundancy in the structure was considered strength.

Results of the Unpacking Exercise

The results of the unpacking are given in Table 4. The exercise used the aquaculture – derived unpacking as a starting point and thus greatly benefited from its structure. There were many elements that could be easily incorporated here. However, as with aquaculture, focus in the exploratory unpacking was on the

conservation of the physical and chemical properties of the ecosystem, although issues in relation to the other objectives were recognized. Unpacking of these objectives would require further workshops. A total of 24 operational objectives were unpacked. As with the other examples, further work would be required to identify reference points.

Table 4. Unpacking of Conceptual Objectives of the Conservation of Physical and Chemical Properties Branch of the Sidney Structure

Conceptual Objective	Operational Objective
• No significant adverse alteration of Seabed Quality ➢ No significant adverse alteration of benthic structural/functional features (abiotic and biogenic)	
• No significant adverse alteration of natural scales of physical/biological variability (i.e. structural, heterogeneity, patchiness, complexity, sediment texture, bottom relief) beyond an authorised (S. 35(2)) zone of influence	• Limit % cover of bottom type X to below Y% within zone of influence • Limit % cover of bottom type X to below Z% (e.g. HADD limit) beyond zone of influence (expect Z << Y)
• No significant adverse alteration of essential/critical habitats	• Restrict % cover of bottom type X to below Z% (low value) within area of critical habitat
• No significant adverse alteration of number of zones of influence in IM area	• Restrict total area of zone of influence to X%
➢ No significant adverse alteration of Sediment quality that support biological structure and function	
• No significant adverse alteration of natural variability in surficial sediment porosity, interstitial space, DO penetration beyond an authorised (S. 35(2)) zone of influence	• Limit change of indicator to Y% within zone of influence • Limit change of indicator to Z% (e.g. HADD limit) beyond zone of influence (expect Z << Y)
• No significant adverse alteration of natural geochemical conditions (e.g. S, Eh, quality and quantity of organic matter, Corg:N, trace elements) beyond an authorised (S. 35(2)) zone of influence	• Limit change of indicator to Y% within zone of influence • Limit change of indicator to Z% (e.g. HADD limit) beyond zone of influence (expect Z << Y)
• No significant adverse alteration of conditions for natural microbial community function (e.g. benthic aerobic/anaerobic respiration)	• Limit change of indicator to Y% within zone of influence • Limit change of indicator to Z% (e.g. HADD limit) beyond zone of influence (expect Z << Y)
• No significant adverse alteration of Water Quality ➢ No significant adverse alteration of physical properties (e.g. currents, stratification, temperature) that support biological structure and function	• Limit changes in current and dispersion to X% • Limit changes in water temperature to X degrees • Limit changes in water salinity to Y ppt
➢ No significant adverse alteration of light spectral quality • Limit dissolved and particulate inputs from oil & gas activities to environmentally acceptable levels	• Maintain input X below RP

Conceptual Objective	Operational Objective
➢ No significant adverse alteration of acoustic environment (quality / quantity) ➢ No significant adverse alteration of nutrient levels ➢ Limit contaminant concentrations to those below which biological effects are observed	• Do not use sound at X frequency and Y intensity during Z season • Limit change in Nitrogen to X% • Limit petroleum hydrocarbons, heavy metals, process chemicals, drilling muds & fluids, NORMS to below RPs
❖ No significant adverse alteration of Biota Quality ➢ Limit bioaccummulation of contaminants ▪ Limit contaminants to below biologically acceptable levels ➢ Avoid food chain contamination ▪ Further unpacking required	• Do not exceed standards for contaminant loads E.g. tissue residue in species X of contaminant Y should not exceed RP

Concluding Remarks

Overall, participants considered the exercise useful but noted the need for more regional and national dialogue on the approach and further unpacking exercises to address issues raised.

OVERVIEW COMMENTS BY THE AUTHORS

The three workshops, while independently planned and coordinated, all sought the same ends – testing the unpacking of the Sidney ecosystem objectives hierarchy in support of ocean management. Each examined the hierarchy from a different perspective, which when considered together, affords an opportunity to consider the overall utility of the approach and profitable directions for future consideration. Below then is summarized some of the main conclusions that the two chairs of these exercises gleaned from the exercises.

Objectives Framework

Each group generally found inadequacies in the hierarchy and recommended that the high level conceptual objectives be rephrased to meet particular concerns that they raised. However, as was noted in the Sidney workshop, reaching consensus by one group could result in lack of consensus by another. A better approach would be to leave the structure as is but immediately unpack down one level to explicitly state what is intended by the higher level objectives. That way, one is always working from the same overarching objectives and thus the debate would be as to how these are interpreted. It was advocated that all intermediate steps in the unpacking should be explicitly stated. Thus, the development of the operational objective from the conceptual will be clear.

Regarding the objectives themselves, it was noted that the Sidney objectives include the verbs 'maintain' and 'conserve' in different parts of its structure. These terms can mean different things to different people and their meaning needs

clarification. Overall, it would be useful to use a relatively unrestricted term, which allows groups to adapt the unpacking to particular local circumstances.

Comments were made that the framework was redundant, with achievement of objectives on one branch likely resulting in achievement elsewhere in the hierarchy. This is not necessarily a bad property but does highlight the need to consolidate all the objectives at the end of the process to ensure that objectives from different parts of the hierarchy are consistent and not counter to each other. Having different objectives in different branches of the hierarchy supporting each other should be considered a positive feature. A bigger concern was divergence by different groups in the development of the objectives. Again, this highlights the need for unpacking of the whole hierarchy followed by careful review to identify areas of convergence and divergence. It is interesting to note that, in the aquaculture unpacking, two separate groups developed objectives that were on the road to convergence.

Concerns were raised that there are linkages between objectives in the hierarchy – achieving the productivity objective necessitates achieving the diversity objective. Again, this highlights the need to consider all branches of the hierarchy in the unpacking.

Indicators and Reference Points

Often, the workshops could not define operational objectives due to the lack of research on appropriate indicators and reference points. In other instances, participants were challenged to consider current indicators and reference points to meet new objectives. Indeed, sometimes discussion was raised on exactly why current indicators were being used. The framework has the potential to guide future research activities to define the indicators and reference points needed for ecosystem based management.

Unpacking Process

There was an overall recognition that the unpacking should attempt to define operational objectives for all three branches in the same exercise. While redundancies might occur, these can be addressed after the unpacking of the three branches has been completed. Focusing on one branch will miss issues and diminishes the overall intent of the exercise – definition of a suite of operational objectives to address all potential impacts on the ecosystem of the ocean activity under study. The experience of these workshops was that who participates generally drives the resulting structure. The three workshops highlighted the need to carefully manage the unpacking process itself. The fisheries unpacking was dominated by, naturally, fisheries scientists and resulted in unpacking the diversity and productivity branches of the hierarchy. The habitat branch was untouched. The aquaculture unpacking consisted mostly of habitat and aquaculture scientists and the unpacking focused on the 'habitat' branch, although comment was made on the need to consider the other two branches. The oil and gas unpacking consisted of scientists working predominately in this discipline and the workshop focused on the 'habitat'

branch. If a balanced unpacking of the whole is desired, then there needs to be scientists participating from all disciplines.

There was concern voiced as to the overall efficiency of the process. Unpacking each objective of the hierarchy could lead to long and unwieldy meetings, particularly if clients are involved. However, it was considered advantageous to consider an objectives structure such as that of the Sidney workshop. The requirement then is to experiment with different workshop organizational models to ensure that the unpacking is undertaken efficiently towards a common goal.

Besides the comments made above, there was a general recognition that we should experiment more fully with the unpacking process before involving clients. The structure of the process is still very much in the early stages of experimentation. Further unpacking will also lead to more understanding of the process and its vocabulary both regionally and nationally.

Overall, the three workshops were an important first step towards realization of ecosystem-based management of Canada's oceans.

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APPENDICES

Appendix 1. Participation at Workshops*

Groundfish Fishery Impacts: 1 February 2002- BIO
O'Boyle, R.; RAP/BIO (chair)
Halliday, R., MFD/BIO
Zwanenburg, K.; MFD/BIO
Hurley, P. ; MFD/BIO
Fanning, P.; MFD/BIO
Annand, C.; RAB/MH
Rudd, M.; PEB/MH

Aquaculture Impacts: 25 – 26 June 2002 - GFC
Black, Edward; NHQ, OSAB
Burridge, Les E; MESD/SABS
Chang, Blythe D; AD/SABS
Courtenay, Simon; ES/GFC
Cranford, Peter; MESD/BIO
Duggan, Dave: OEB/BIO
Fanning, Paul; MFD/BIO
Hargrave, Barry; MESD/BIO
Haya, Kats; MESD/SABS
Keizer, Paul; MESD/BIO (chair)
Lawton, Peter; IFD/SABS
Locke, Andrea; ES/GFC
Martin, Jennifer L; MESD/SABS
Milligan, Timothy; MESD/BIO
O'Boyle, Robert; RAP/BIO
Page, Fred H; OSD/SABS
Ross, Jim; HMD/BIO
St-Jean, Sylvie; ES/GFC
Strain, Peter; MESD/BIO
Wildish, Dave J; MESD/SABS

Oil and Gas Development Impacts: 29 July 2002 - BIO
Fenton, D; OEB/BIO
Head, E; OSD/BIO
Keizer, P; MESD/BIO
Lee, K; MESD/BIO
Loder, J., OSD/BIO
O'Boyle, R; RAP/BIO (chair)
Potter, T; OEB/BIO
Ross, J; HMD/BIO

*All participants were DFO employees. The abbreviations are as follows:

AD	Aquaculture Division, MSB
BIO	Bedford Institute of Oceanography, Dartmouth, NS
ES	Environmental Science Section, Oceans Branch, Gulf Region
GFC	Gulf Fisheries Centre, Moncton, NB
HMD	Habitat Management Division, Oceans and Environment Branch,
IFD	Invertebrate Fisheries Division, MSB
MESD	Marine Environmental Science Division, MSB
MFD	Marine Fisheries Division, MSB
MH	Marine House, Dartmouth, NS
MSB	Science Branch Maritimes Region
MOEB	Maritimes Region
NHQ	National Headquarters
OEB	Oceans and Environment Branch, BIO
OSD	Ocean Sciences Division, MOEB
PEB	POLICY AND ECONOMICS BRANCH, MARITIMES REGION
RAB	Resource Allocation Branch, Maritimes Region
RAP	Regional Advisory Process Office, MSB
SABS	St. Andrews Biological Station

Appendix 2. Workshop Terms of References and Agendas

Groundfish Fishery Impacts: 1 February 2002 - BIO

Given that page 10 of the draft Scotian Shelf Groundfish IFMP outlines general objectives, strategies and management measures for the plan, at least in the short term:

- Review the overall objectives hierarchy to ensure that the Environmental Dimensions (conservation of groundfish and conservation of ecosystem) are consistent with national thoughts on this. The Dunsmuir report at http://www.mar.dfo-mpo.gc.ca/science/rap/internet/Home.htm as CSAS Proceedings 2001/09 provides this.

- Consider a similar hierarchy for the socio-economic and institutional Dimensions. There is no national guidance on these as yet (recommended at Dunsuir). We should at least agree among ourselves with the top levels.

- For the various branches of the hierarchy, state the conceptual objective being sought. These should be close to what is on page 10.

- For each conceptual objective, to the extent possible, undertake an unpacking exercise as per Dunsmuir to obtain operational objectives

Aquaculture Impacts: 25 – 26 June 2002 - GFC

	Tuesday, June 25, 2002	
0900	Introduction – purpose of meeting, review of agenda/approval and arrangements	P. Keizer
0915	The ecosystem objectives framework – an overview and an example of an application.	R. O'Boyle
1000	AN OUTSIDERS VIEW OF THE ECOSYSTEM OBJECTIVES FRAMEWORK – Including relationship to MEQ and HADD	P. Keizer
1045	Health break	
1100	Unpacking the framework - process, hierarchical approach	P. Keizer
1130	Breakout groups (2) - unpacking the framework for aquaculture - objectives	
1230	Lunch (provided)	
1330	Plenary session – report of breakout groups and developing a common framework	
1500	Multivariate performance indicators - the index of biotic integrity/alternate biological end-points - the traffic light approach - DSS for aquaculture	S. Courtenay P. Fanning B. Hargrave
1530	HEALTH BREAK	
1545	Multivariate performance indicators (cont'd)	
1615	The Australian experience	D. Wildish
1730	Adjourn	

	Wednesday, June 26, 2002	
0900	Recap and next steps	P. Keizer
0915	Operational objectives and Performance indicators • Breakout groups (2)	
1030	Health break	
1045	Plenary – common list of performance indicators	
1130	Reference points and targets – dare we go there?	
1230	Lunch (provided)	
1330	Evaluation and next steps	
1500	Adjourn	

Oil and Gas Development Impacts: 29 July 2002 - BIO

None formally stated other than to conduct illustrative unpacking exercise on oil and gas impacts using the aquaculture unpacking workshop report as a guide.

Appendix 3. Strawman Proposal for Unpacking of Aquaculture Impacts

- Institutional
  - MPA location
  - Monitoring compliance
- Social
  - Proximity to human habitation
  - Maintain contaminant levels below CFIA RPs
- Economic
  - Indicators of site productivity
  - Maintain homeostasis
- Environmental
  - Conserve ecosystem components
    - Maintain Communities
      - Impacts on habitat diversity
      - What about broader impacts on other species through accidental introductions?
      - Creation of new habitat
    - Maintain Species
      - Bay of Fundy Salmon might be a consideration
    - Maintain Populations
      - Impacts on genetics of natural populations
  - Conserve component's role
    - Maintain primary production
      - Could broader eutrophication effects go here? Cumulative nutrient loading
      - Other nutrient sources?
    - Maintain trophic structure
      - Could broader eutrophication effects go here? Cumulative nutrient loading
      - Other nutrient sources?
      - Impacts on critical habitat (nursery, spawning areas, etc)
      - Impacts on salmon, herring, lobster & other species, etc migrations
      - Impacts on predator-prey relationships
      - Could this be where carrying capacity & cumulative impact indicators go?
    - Maintain mean generation times of populations
      - Impacts on wild population productivity
  - Conserve physical & chemical properties
    - Conserve critical landscape & bottomscape features
      - Maintain natural abiotic & biotic structures relative to environmentally <u>acceptable</u> conditions / baseline (pre-development)?
        - Minimize loss of critical local structures
          - Maintain % cover of bottom type X to below Y%

- Conserve bottom sediment quality
  - Maintain geochemical conditions to acceptable levels
    - Maintain Eh, sulphide, organics, water content, and / or grain size above RP
  - Limit anthropogenic inputs from aquaculture operations
    - Maintain heavy metals, drugs, pesticides, etc above RP
- Conserve water column properties
  - Maintain water currents relative to acceptable conditions / baseline?
    - Minimize profile of site through design & placement
      - Further unpacking required
  - Maintain physical features (ice cover, currents, fronts, stratification, freshwater inputs) at historical average levels
    - Further unpacking required
  - Maintain sound quality within environmentally acceptable levels
    - Limit sound at x frequency & y intensity during z season to RP
- Conserve water quality
  - Maintain dissolved oxygen within environmentally acceptable levels
    - Maintain DO concentration deviates within low & high RP
  - Maintain nutrients within environmentally acceptable levels
    - Maintain nutrient loadings to above environmentally acceptable levels
      - Further unpacking required: RPs must be determined in context of receiving environment
  - Maintain temperature and salinity
    - Further unpacking required
  - Maintain light spectral quality
    - Limit dissolved & particulate inputs from aquaculture activities to environmentally acceptable levels
      - Limit input x to above RP
    - Limit activities that directly influence light field
      - Limit shading of site to x % cover
      - Limit candle power to below RP
    - Limit activities that indirectly influence light field
      - Further unpacking required
  - Limit anthropogenic inputs
    - Limit anthropogenic inputs from aquaculture operations
      - Limit heavy metals, drugs, pesticides, etc to above RPs
    - Limit anthropogenic inputs from activity x
      - Limit heavy metals, drugs, pesticides, etc to above RPs
- Conserve biota quality
  - Maintain health of wild organisms
    - Limit contaminants to below biologically acceptable levels
      - Do not exceed standards for contaminant loads
        - Tissue residue in species x of contaminant y should not exceed RP
    - Limit disease impact of aquaculture activities
      - Further unpacking required